been conducted not long after the increased requirements were enforced. Thus, there may have been little opportunity for revisions and improvement.

Several studies point to possible negative effects of stronger coursetaking requirements. For example, minority and at-risk students failed more courses than they did before stronger mandates were put into practice (NECTL 1994). Opinions differ on the quality of the additional courses taken, especially those taken by low-achieving students. There has been particular concern about the quality of new mathematics courses designed for low achievers, who, under a traditional curriculum, would have taken general or basic mathematics. Research suggests that implementation of state-level mandates for stronger coursetaking requirements varies greatly across districts and schools. Studying 18 high schools in 12 districts in 6 states, Porter, Smithson, and Osthoff (1994) found some schools pushing students into demanding content in higher level course while others did not. Furthermore, Gamoran (1997) found that bridging courses, those designed to prepare lower achieving students for college-preparatory courses, achieved some success in improving student achievement. Research in this area is inadequate, however, for evaluating whether or not the increase in state-level curricular requirements have changed the level of difficulty or quality of mathematics and science courses offered to students.

Additional studies accessing the content of the mathematics curriculum, as well the quality of 8th grade mathematics instruction, are described in the section on Curriculum and Instruction. Strengthening course-taking requirements is only one component of most educational reform strategies, however. The next section examines states' attempts to implement state-wide curricular frameworks, as well as assessments of the underlying content.

Content Standards and Statewide Assessments

In the 1980s, most states approved policies aimed at improving the quality of K–12 education, implementing statewide curriculum guidelines and frameworks as well as assessments. At present, half of the states require students to pass some form of exit examination to graduate from high school, and others report developing such tests (CCSSO 2000a). Underlying this reform agenda is the assumption that these standards and assessments will lead to higher student achievement. However, assessments and standards are not always tightly linked, and the implied performance incentives for students, teachers, and administrators vary across states. Furthermore, there is concern that some state-level assessments focus too much on facts, even though the associated standards call for complex scientific inquiry. This section reviews the national data available concerning the implementation of standards and assessments across states. Particular attention is paid to the alignment of these new standards and assessments to student achievement by reviewing recent research in this area.

Adoption of Content Standards

State-level content standards are typically intended to provide the basis for state and local decisions on curriculum, texts, instructional materials, student assessments, teacher preparation and professional development, and other components of programs of instruction (CCSSO 2000a). CCSSO reported that, by 2000, 49 states had established content standards in mathematics and 46 states had established standards in science (CCSSO 2000a). Teachers remain concerned, however, that standards do not always provide clear guidance regarding the goals of instruction and that schools do not yet have access to top-quality curriculum materials aligned with the standards (Achieve 2000). The next section highlights some issues regarding the degree to which states require or facilitate the alignment between instructional materials and standards.

Statewide Policies on Textbooks and Standards

One way that states can influence the implementation of mathematics and science standards is to select or recommend textbooks and curriculum materials for schools that are aligned with their standards. Fewer than half of the states, however, mandate or recommend particular textbooks and curriculum materials. The Council of Chief State Officers reported that a total of 21 states had a state policy regarding textbooks and curriculum materials for classrooms, as of spring 2000 (CCSSO 2000a). Among the total, 11 have a state policy defining state selection of textbooks and materials to be used and another 10 recommend texts or materials to the local districts. In 2000, 20 of the 21 states with a textbook policy use their state content standards to select or recommend curriculum materials, the same as in 1998.

Some examples of state policies on textbooks include California, where content standards and frameworks are used to select the materials that will be adopted by the State Board of Education and recommended to school districts and Tennessee, where the state adopts an approved list of curricular materials from which local schools boards may then choose and receive state funds. These policies contrast with those of Alaska and New Jersey, where textbook selection decisions are left up to the local boards. As noted above, most states do not have a statewide policy on aligning textbooks and standards (CCSSO 2000a). (See sidebar, "States Band Together to Create a Market for Standards-Based Materials").

State Assessment Programs in Mathematics and Science

Nearly all states conduct statewide assessments in mathematics, although the grades assessed and the type of test vary widely. Results of the most recent CCSSO Annual Survey of State Student Assessment Programs (for the 1998/99 school year) show that 48 states have a statewide program in one or more subjects (CCSSO 2000a). Although many states have administered statewide assessments of student learning since the 1970s, additional states approved policies requiring

States Band Together to Create a Market for Standards-Based Materials

Although some states set statewide curriculums and approve textbooks for statewide use, the development and use of curricular materials is typically the responsibility of a local school district or a school. Because most of the materials used in schools come from commercial publishers, obtaining curricular materials that are well aligned to a school's curriculum is a challenge. One way in which states can influence the development of standards-based materials is by banding together to create a larger market. One example of this is the Mathematics Achievement Partnership (MAP), a consortium of 11 states brought together by Achieve, Inc., an independent, bipartisan, nonprofit organization created by governors and corporate leaders to help raise standards and performance in American schools. MAP is developing a common set of expectations for middle school mathematics, and participating states will administer an 8th-grade assessment based on these expectations. Although the partnership plans to develop materials, it may also create enough of a market to encourage publishers to align their materials with the expectations the states have jointly produced.

SOURCE: Achieve 2000.

statewide student testing throughout the 1980s and 1990s, and the number of subjects and grades to be assessed increased. Important factors in the growth of state policies are greater interest in accountability tied to student performance; needs for assessing learning growth related to policies and programs; and federally funded programs linked to state assessments of learning, such as Title I and the Individuals with Disabilities Education Act (CCSSO 2000a).

In academic year 1998/99, 48 states required statewide assessments in mathematics, up from 34 states in 1984 and 45 states in 1994; 23 states started at grade 3 or earlier and nearly all states assessed at least one grade near the end of high school. Thirty-one states administered norm-referenced tests and 40 administered criterion-referenced tests (CRT).[7] Twenty-five states administered both, depending on the grade and the purpose of the assessments. All states had multiple-choice items on their tests, although 26 states included short-answer questions and 27 included extended-response items as well. Only two states included individual performance assessments as part of their testing program, and another two included reviews of portfolios or learning records.

Fewer states have statewide assessment programs in science; there were 33 in 1998/99, up from 13 in 1983/84 and 30 in 1993/94. Among these states, 19 administer norm-referenced tests, 23 administer criterion-referenced tests, and 9 use some combination of both at different grades. As with mathematics, multiple-choice items are included on each state's tests, although 12 states include short-answer questions, 12 states include extended-response items, and 6 states included some means of performance assessment (CCSSO 2000a).

Public Support for Standards and Testing

Although some states have recently delayed the introduction of high-stakes tests (i.e., tests that students must pass to either graduate or advance a grade), public support for standards and testing remains strong. In September 2000, the nonprofit, nonpartisan research organization Public Agenda conducted a national survey of parents to gauge whether there had been backlash against standards. The study contained both a nationally representative sample of parents and a sample of parents in districts that are actually implementing higher academic standards (Public Agenda 2000).[8]

This study found that only 2 percent of parents who knew that their school district was implementing higher academic standards wanted to return to previous practice. Fifty-three percent wanted to continue with the effort as planned, and one in three (34 percent) wanted to continue with some adjustments. Additional interviews in Boston, Chicago, Cleveland, Los Angeles, and New York (five cities with highly visible efforts to raise standards) returned similar results. More than 8 in 10 (82 percent) parents who knew their school district was implementing higher standards believed their schools had, in fact, been "careful and reasonable" in putting the new standards in place.

Relatively few parents in the study said that their child's school requires them to take too many standardized tests to the detriment of other important learning (11 percent), that teachers in their child's school "focus so much on preparing for standardized tests that real learning is neglected" (18 percent), or that their child receives too much homework (10 percent). Furthermore, three out of four parents agreed that "students pay more attention and study harder if they know they must pass a test to get promoted or to graduate," and a similar proportion agreed that "requiring schools to publicize their standardized test scores is a wake-up call and a good way to hold schools accountable."

Parents did not feel, however, that promotion or graduation decisions should be based on a single test. Almost 8 in 10 (78 percent) agreed that "it's wrong to use the results of just one test to decide whether a student gets promoted or graduates." (See sidebar, "Employer and College Professor Perceptions of How Well Young People Are Prepared for Work and College.")

[7]Norm-referenced tests compare the scores of test takers with those of a representative, usually national, sample of students who have taken the test previously. Criterion-referenced tests (CRTs) are designed to indicate the degree of mastery of skills that have been taught. CRTs report how well students are doing relative to a predetermined performance level on a specified set of educational goals or outcomes included in the school, district, or state curriculum (Bond 1996).

[8]This survey was based on a national random sample telephone survey of 803 parents of public school students in grades K–12. The margin of error for the national sample is ±3 percentage points. Oversamples were conducted with at least 200 additional parents of students who attend public schools in Boston, Chicago, Cleveland, Los Angeles, and New York, where the margin of error for each oversample city is ±7 percentage points.

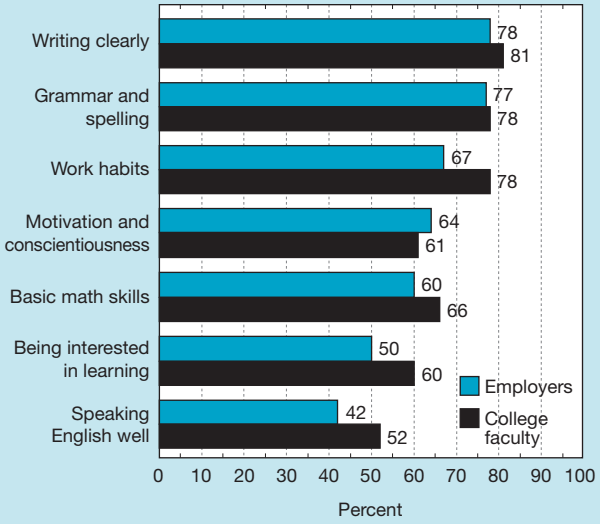
Employer and College Professor Perceptions of How Well Young People Are Prepared for Work and College

Employers and professors are far more disapproving than parents or teachers of how well young people are prepared for college and work, and very large majorities continue to voice significant dissatisfaction about students' basic skills. This finding comes from a recent "Reality Check" Survey by Public Agenda, a nonprofit, nonpartisan research group. (See figure 1-9.) This survey tracks whether efforts to set high education standards have made a difference by interviewing the students and teachers in public schools, the parents of those students, and the employers and college professors who deal with recent graduates. Employers and college professors were asked how they would rate recent job applicants/freshmen and sophomores across different topics, including clear writing, work habits, motivation and conscientiousness, and basic math skills. About two-thirds of professors found the basic math skills of recent freshmen and sophomores to be only "fair" or "poor." About 80 percent stated that student ability to write clearly was only "fair" or "poor." These results point to the continuing gap between student skill level and preparation for college and college professor views of the adequacy of that preparation. Results were similar for employers regarding recent job applicants. Both professors and employers support testing, with employers more likely to support testing of basic skills and professors more likely to support a test "showing that they (high school graduates) have learned at higher levels." Less than 10 percent of both groups reported thinking that "requiring kids to pass a test" before receiving a high school diploma is a "bad idea." (See figure 1-10.)

The responses above were derived from telephone interviews conducted in November and December 2000 with national random samples of 251 employers who make hiring decisions for employees recently out of high school or college and 254 professors at two- and four-year colleges who taught freshmen or sophomores in the last two years. The margin of error for employers and college professors is ±6 percentage points.

SOURCE: Public Agenda Online 2001.

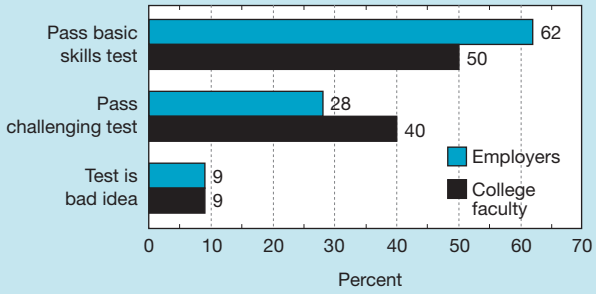
Figure 1-9.
Percentage of employers and college faculty who rated job applicants/freshman and sophomore students as "fair" or "poor" on various activities: 2000



SOURCE: Public Agenda, *Reality Check 2001,* http://www.publicagenda.org/specials/rc2001/reality6.htm. Accessed 8/20/2001.

Science & Engineering Indicators – 2002

Figure 1-10.
Employee/faculty support for high stakes testing: 2000[a]



[a]Data are based on responses to the following question: Before students are awarded a high school diploma, would you want the school district where you work/teach to require students to pass a basic skills test in reading, writing, and math; pass a more challenging test showing they have learned at higher levels; or do you think requiring kids to pass a test is a bad idea?

SOURCE: Public Agenda, *Reality Check 2001,* http://www.publicagenda.org/specials/rc2001/reality6.htm. Accessed 8/20/2001.

Science & Engineering Indicators – 2002

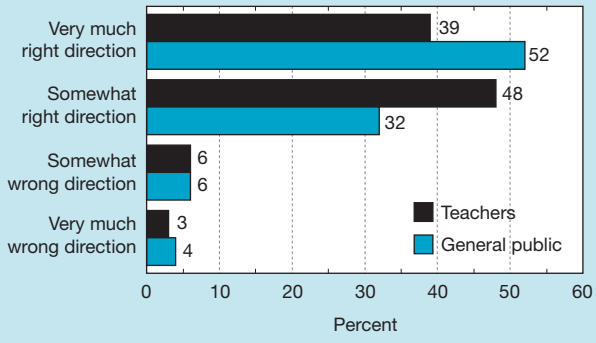
Attitudes of Teachers on Academic Standards and State Testing

The success of reforms based on state-wide standards and high-stakes testing rests to a large extent on the commitment of teachers to align their teaching to the standards. In September 2000, *Education Week* sponsored a survey of public school teachers to find out whether they thought that the academic standards being put into place are helping them teach children better. Specifically, teachers were asked whether they find the standards useful or a hindrance, whether they have enough time and resources to understand the standards and integrate them successfully into their lesson plans, and whether they feel the current tests are helping to assess student abilities or are taking up too much classroom time. Finally, teachers were asked whether they believe students are learning more (Belden, Russonello, and Stewart Research and Communications 2000). The findings of this survey are summarized below.

How Do Teachers View Academic Standards?

Public school teachers generally support the movement to raise standards, but they are less supportive than the general public. (See figure 1-11.) Nearly 9 out of 10 teachers said that raising academic standards for what students should learn each year and before they graduate is a move in the right direction, 39 percent said it is very much in the right direction, and 48 percent said it is somewhat in the right direction. Nearly three-quarters of teachers said that the academic standards for students in the state where they live are "about right," 5 percent said the standards are too high, and only 7 percent said that standards are too low. These findings were similar for mathematics and science teachers.

Figure 1-11.
Opinion of teachers and general public on move to raise academic standards: 2000



NOTE: Data are based on answers to the following:
Many states are adopting new standards for what students should learn each year before they graduate. In general, do you believe the emphasis on raising academic standards is a move in the right or in the wrong direction?

SOURCE: Belden, Russonello, and Stewart Research and Communications, *Making the Grade: Teachers' Attitudes Toward Academic Standards and State Testing: Findings of National Survey of Public School Teachers for Education Week* (Washington, DC: 2000).

Science & Engineering Indicators – 2002

A larger proportion of the general public supports the direction of the standards movement, and these supporters are more likely than teachers to say that the current standards are too low. On a national survey conducted in August 2000, 52 percent of Americans believed the movement to adopt new standards is very much in the right direction, and 32 percent believed that it is somewhat in the right direction (Public Agenda 2000). Only 42 percent of the general public said that the current standards are about right, 5 percent said they are too high, and 47 percent said they are too low.

Do Teachers Believe That Their Students Are Meeting Standards?

Nearly two-thirds of public school teachers said that all or most of their students are currently meeting the standards for their grade, and only 8 percent said that a few or none of their students are meeting standards. Suburban teachers, teachers in schools where fewer than 10 percent of students are receiving free lunch, and teachers in states with exit examinations were more likely to report that their students were meeting the standards. Teachers in schools with a high percentage of minority students were less likely to say that all or most of their students are meeting the standards.

Do Teachers Think That the Curriculum Has Become More Demanding of Students?

The vast majority of teachers feel that the curriculum is becoming more demanding of students. In the 2000 study cited above, 79 percent of teachers reported that the curriculum is more demanding of students than three years ago: 39 percent reporting a lot more and 40 percent reporting somewhat more. Only 17 percent reported that there has been no change, and 4 percent reported that the curriculum has become less demanding. Elementary school teachers were more likely to say the current curriculum is more demanding, and middle and high school teachers were more likely to say that there has been no change in the level of the curriculum. Teachers in states with exit exams, those teaching a high percentage of minority students, and those teaching where standards have been put in place more recently (since 1995) were more likely than other teachers to report that the curriculum has become more demanding over the three-year period.

Among teachers who reported that the curriculum is more demanding, nearly two-thirds said that this change is the result of new statewide academic standards. An additional 20 percent responded that a combination of other factors and the standards have resulted in the more demanding curriculum, and 16 percent said that it was due solely to other factors. Math teachers were more likely than English, science, or social studies teachers to report new standards as having made the curriculum more demanding, as were teachers in schools where more than 10 percent of the students received free lunch.

How Do Teachers View Testing?

Have the new statewide standards led to teaching that focuses too much on state tests? Two-thirds of teachers said that this is the case: a third stated that statewide standards

had led to far too much time focused on testing, and another third indicated that this was somewhat the case. Most of the remaining teachers said that the focus is just right. Similarly, two-thirds of the teachers surveyed agreed more with the statement, "State testing is forcing you to concentrate too much on information that will be on the test to the detriment of other important areas" as opposed to "State testing is helping you as a teacher to focus on teaching what children really need to know."

How Much Do Teachers Integrate Standards and Testing Into Their Teaching?

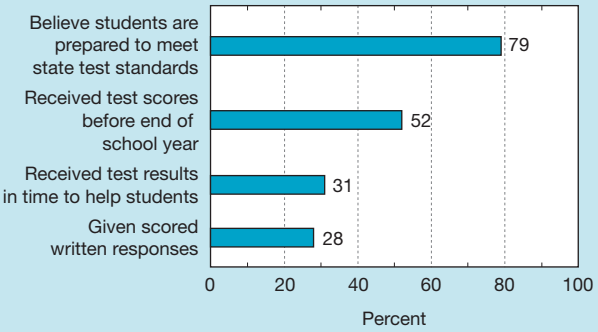
The 2000 *Education Week* survey of public school teachers cited above also indicates that teachers feel prepared to implement state standards in their classrooms, more so than in the previous year (Belden, Russonello, and Stewart Research and Communications 2000). Almost all of the public school teachers (94 percent) reported that they have a copy of the statewide academic standards, and 84 percent said that they have modified their curriculum to reflect the standards (36 percent a "great deal" and 48 percent "somewhat"). A similar proportion said that they have adopted or developed modules, units, or lesson plans linked to the state standards.

A significant amount of "teaching to the test" appears to occur, but using these tests as diagnostic tools is also quite widespread. Nearly 8 out of 10 teachers reported instructing their classes in the previous year in test-taking skills, such as pacing themselves and filling in bubbles clearly (45 percent "a great deal" and 34 percent "somewhat"); 7 out of 10 teachers reported using individual results to help diagnose what students need (36 percent "a great deal" and 34 percent "somewhat"); and 6 out of 10 teachers reported using results to diagnose what they need to be teaching in their classes (32 percent "a great deal" and 42 percent "somewhat"). Nearly two-thirds of teachers said that they had amended what they taught in the previous year to fit what is on the state tests (22 percent "a great deal" and 43 percent "somewhat"). (See sidebar, "High School Teachers Have a Generally Favorable Opinion of State Graduation Tests.") (See figure 1-12.)

While the data in this section have shown that the vast majority of states have adopted content standards in mathematics and science and that state-wide testing in these subjects is increasing, a number of studies raise concerns over the degree to which state tests align with state standards. For example a recent study from the American Federation of Teachers found that "no state or the District of Columbia has a fully developed standards-based system that links quality standards to tests, curriculum and accountability measures" (AFT 2001). This study found that:

- Almost a third of the states' tests are based on weak standards;
- Forty-four percent of those tests are not aligned to the standards;
- Fewer than one-third of the tests are supported by adequate curriculum; and
- One-third of the tests used in decisions regarding promotion or graduation are not aligned to the standards.

Figure 1-12.
Opinion on preparation for and utility of state test by public high school teachers whose state has graduation test: 2000



NOTE: Data are based on responses to the following questions:
Q51. Are students well prepared enough to meet the standards on the tests, or are they ill prepared?
Q52. Last year, did you receive your students' scores on the state exams before the end of the year?
Q53. Last year, did you receive your individual students' test results early enough in the year or too late to be helpful in working with those individuals?
Q55. Are you given copies of your students' scored written responses on the state exams?

SOURCE: Belden, Russonello, and Stewart Research and Communications, *Making the Grade: Teachers' Attitudes Toward Academic Standards and State Testing: Findings of National Survey of Public School Teachers for Education Week* (Washington, DC: 2000).

Science & Engineering Indicators – 2002

While other studies come up with different numbers, the problem of alignment between standards, testing, instruction and accountability remains a common theme (e.g., Achieve, Inc. 2001; CCSSO 2001; Finn and M.J. Petrilli 2000). (See sidebar, "A Survey of Curriculum Use in Classrooms.") Data presented in this section show that both teachers and the general public support standards and testing, although the latter more strongly than the former. The next section examines how the organization of the math and science curriculum in the United States differs from other countries and reviews current measures of the quality of mathematics instruction.

Curriculum and Instruction

Debate continues over the effectiveness of two distinct instructional approaches: (1) emphasis on drill and practice activities in which students work toward skill mastery and (2) emphasis on reasoning, conceptual understanding, and skill application. This debate is driven by differences in opinion regarding the nature of the curriculum as well as different theories about how people learn. Although whole-group instruction and worksheets are still commonly used , the majority of American teachers report using small-group instruction as well as using manipulatives or models to dem-